Method and Apparatus for decontamination of automotiv HVAC systems

FIELD OF INVENTION

This invention relates to the field of passenger vehicles, including light and heavy truck, heating, ventilation and air conditioning systems, particularly HVAC systems, using oxidants as means to reduce contaminants and increase passenger comfort levels in such vehicles.

BACKGROUND OF THE INVENTION

Air treatment systems, such as heating, ventilation and air conditioning systems, perform three principal functions in automotive vehicle applications: heating, cooling and dehumidifying the air inside the vehicle. Air thusly treated leads to more even temperature and humidity control, thereby resulting in treated air for passengers to achieve a good level of passenger comfort. Distribution of air, transfer of heat, condensation of water, and maintenance of a closed (air and water tight) system are the steps used to meet these desired effects.

Current HVAC systems for automotive vehicles suffer numerous problems as it relates to ancillary effects of the primary heating, cooling and dehumidifying activities. One of the chief deficiencies associated with current HVAC functional requirements is the promotion of bacteria, yeast, and fungal growth or development by promoting the ingestion, incubation, and even the continuous distribution of micro-organisms and derived products within the HVAC system and vehicle interior. Contamination of the HVAC system is inevitable, even with the use of filters. The value of filter function is lost when micro-organisms pass through the filter media. The offending organisms include, for example: *alternaria alternata, penicillium cyclopium, trichoderma harzianum, bacillus subtilis, bacillus licheniformis, bacillus cereus, acinobacter calcoaceticus, pseudomonas fluorescens, proteus hauseri, staphyloccus epidermis,* which generally are too small in size and too prevalent to employ traditionally economical solutions or methods to avoid their entry or distribution to or within the HVAC system.

HVAC systems often are described as working in fresh air or 'recirculation' modes. In both fresh air and recirculation mode, organisms are drawn into the HVAC unit. Contamination of the HVAC unit components, including interior surfaces and duct work, necessarily takes place on a continuous basis because the air to be circulated and/or the

circulated air is not sterile. Heat transfer, combined with the condensation of water, provides an environment perfectly suited for organism growth. Engine coolant, circulating through most vehicle heater cores while the engine is running, also transfers heat through the core providing a source of warmth. The presence of water vapor, in the form of relative humidity or condensate carryover, for example, can lead to an HVAC functional environment where maintenance, development and/or the growth of micro-organisms, (as well as a medium for such maintenance, development or growth) is created and even propagated. These conditions are, additionally, being maintained in a system that is generally as air and water tight as possible, with, preferably, only the intended entry and exit open. The HVAC functional environment is, therefore, basically a 'closed' system that will not function at an optional level if other openings are added (or interruptions are made) along the air flow surface.

US Patent 5,788,930 issued in August 4, 1998, McMurray 'Apparatus for Purifying an Environment Using Ozone Generation', addresses the issue of safe and efficient purification of an enclosure, including buildings or vehicles" but does not anticipate the functional requirements of vehicle HVAC systems, and focuses on "efficient purification" in the control of ozone concentrations.

US Patent 5,648,046 issued in July 15, 1997, Weibel 'Method and System For disinfecting Air In Air Conditioning Ducts,' describes a method for disinfecting air in ventilation ducts by the use and application of a vaporized ammonia solution that is ionized and distributed within a set of grounded duct work; ionized vapor migrates to the interior walls of the duct due to the 'grounding effect', thereby reducing bacteria and mold growth by utilizing the bactericidal properties of ammonia. This reference does not disclose, suggest or anticipate such an application within a vehicle HVAC system.

US Patent 3,750,556 issued in August 7, 1973, Douglas Roy Duke et al 'Air Purifying Means,' relates to an "apparatus for conditioning the air being circulated through a confined space". It does not disclose, suggest or anticipate the HVAC system as a primary source of contamination and would be an ineffective means of addressing the herein described HVAC specific problems, such as the growth or development ('contamination') of microorganisms on an evaporator.

US Patent 5,810,896 issued September 22, 1998, Clemens, 'Air filtration and purification system for vehicle,' discloses an air filtration and purification system for the interior of a closed vehicle, more particularly, a system mounted in the interior of a closed vehicle wherein polluants are prevented from influxing from outside the vehicle.

US Patent 5,938,523 issued August 17, 1999, Khelifa et al ,'Device for removing the noxious and aromatic substance from an air flow fed into the interior of a vehicle,' discloses an absorbent containing device to absorb noxious and aromatic matter.

US Patent 5,942,026 issued August 24, 1999, Erlichman et al, 'Ozone generators useful in automobiles,' described inlet air ionization structures useful to produce ozone of the inlet of an internal combustion engine. Column 3 describes ozone in the interior of the filter housing, and that ozone assists in flame propagation inside the combustion chamber.

US Patent 5,762,665 issued June 9, 1998, Abrahamian et al, 'Vehicular air purification system,' discloses a vehicle air purification system having specific outlet vents. In column 5, its plurality of components include active and passive filter units.

US Patent 4,658,707 issued April 21, 1987, Hawkins et al, 'Automatic air purifier for vehicles' describes an air purifier which can be positioned within various places in a confined space such as a vehicle interior where smoke may be present' to purify the air therein. It further describes an air filter for filtering tobacco smoke and other airborne impurities.

SUMMARY OF THE INVENTION

The present invention relates to a means for providing for increased passenger comfort in an automobile vehicle. More particularly, the present invention provides increased passenger comfort in an automobile passenger compartment. To provide adequate passenger comfort as described above, four general processes are normally required: distribution of recirculated or fresh air, transfer of heat, condensation of water, and maintenance of a closed (air and water tight) system. The present invention further provides an increased level of passenger comfort by providing a means for addressing

the prior art problem of air-borne elements that reduce passenger comfort , particularly those related to conditions that lead to an HVAC functional environment that creates a breeding ground for bacteria, yeast, mold and fungal growth, and the like. The growth of micro-organisms significantly impacts passenger comfort due to contaminating allergens and odors. The present invention, therefore, further provides a method to control contaminants related to microbiological growth, development or maintenance and associated allergens related thereto in an HVAC functional environment, thereby reducing odors and promoting passenger comfort.

The present invention, as described above, provides a means for increasing passenger comfort in the vehicle passenger compartment. Particularly, the present invention provides a means to prohibit, inhibit or reduce bacteria, yeast, mold and/or fungal growth, development or maintenance, within or associated with the HVAC system, thereby controlling formation, growth and/or concentration of odors and, in particular, 'off' or 'offensive' odors or allergens which might accompany such micro-organisms or related substances. Preferably ozone is employed, within the HVAC system, as the principal element to control the formation, growth, development or maintenance of micro-organisms that leads to undesirable odor or allergen substances. The present invention, therefore, provides a means for oxidant, and, preferably, ozone generation integrated within the HVAC system, thereby taking advantage of the 'closed' characteristics of the system. This allows for the oxidant to be delivered directly to the contaminated components and surfaces. In addition, the present invention allows for the vehicle manufacturer to specify the oxidant concentration, time of delivery, and duration of exposure within the limits described herein below and, preferably, to best meet both performance and packaging requirements by providing multiple locations for oxidant generator placement.

The present invention further provides an HVAC apparatus comprising an HVAC unit, at least one ozone generator, at least one sensor means for detection ozone level, at least one control means for regulating ozone levels in the HVAC unit.

The present invention achieves a 'decontamination' or inhibition of organism growth on both the surfaces and interior components of the HVAC unit by creating an environment

that is harmless to humans but septicidal, (bactericidal, bacteristatic, fungicidal or static, etc, or the like) for micro-organisms including bacteria, molds, yeast, fungi and the like. The present invention further preferably provides for the aspect of a feedback loop mechanism to sense oxidant concentration in the cockpit or passenger compartment of a motor vehicle, and the HVAC unit. By placing an oxidant sensor means, and, preferably, an ozone sensor in the cockpit or passenger compartment, preferably at a low level in the passenger compartment (such as on a level in line with the level of the accelerator pedal or below on a standard vehicle), at ozone levels deemed too high or otherwise unacceptable, ozone would cease to be generated, derived, transported or otherwise received into the HVAC unit. Decontamination would cease until ozone levels were again at an acceptable level in the cockpit or passenger compartment. This control preferably is achieved via a feedback mechanism involving, at a minimum, the generator and the sensor described herein. The present invention as described herein can be used at all times, as long as the level of ozone in the cockpit or passenger compartment does not rise to unacceptable levels. Preferably, the method of preferred aspects of the present invention are operated when there are no passengers within the cockpit or passenger compartment of the motor vehicle.

It is clear that the prior art addresses many issues related to the environmental problem of so-called 'in-door' air pollution. However none of the art cited above directly addresses or even appreciates or fully comprehends the root problem with respect to vehicle HVAC systems, that of a "functionally driven contamination". Air purification is the focus of these other inventions, not issues such as asepsis and the like or other controls of contaminants within the HVAC unit or in the HVAC functional environment.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is elevational cross-section view of an HVAC apparatus in accordance with an aspect of the present invention.

Fig. 2 is a representation of an oxidant, in particular, ozone, in accordance with an aspect of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

While prior art describes the terms "efficient purification" or air purification focused on the control of element concentrations, the present invention focuses on the distribution of the oxidant within the vehicle, the distribution problem to be solved. In one aspect of the present invention, the timing of the generator operation and ozone generator design provide the necessary controls to prevent "over ozonation".

The molded materials, and, in particular, the plastic and plastic like materials from which an HVAC unit and ducts are, preferably, made, cannot be sufficiently grounded for the interior surfaces to attract disinfection means such as ionized vapor to proport a solution. Water vapor, as a conductive medium, potentially causes electrical shorts to occur in several components of the HVAC unit, including the resistor and blower motor. Products like ammonia, that might disinfect the air conditioning system of a vehicle, carry their own objectionable odors of long duration, that would be offensive to most vehicle owners.

The present invention preferably provides for the use of oxidants, and, preferentially, ozone, to solve the decontamination or asepsis problem. Ozone has a half life that has been measured from less than a minute to up to 12 minutes. Any odor associated with ozone would dissipate soon after its manufacture.

In a preferred method of the present invention, a good level of passenger comfort is achieved by: placing an ozone generator above the heat exchangers of a vehicle HVAC system; utilizing a vehicle controller to activate and time the ozone generator operation; and distributing ozone within the HVAC system by gravity feed.

Preferably the amount of ozone or ozone concentration level employed in preferred embodiments of the present invention in the HVAC functional environment is between about 8 ppm and 0.045 ppm, more preferably between about 1.0 ppm and 0.045 ppm, even more preferably from about 0.1 to 0.045 ppm. Preferably, the ozone concentration level is maintained from one to eight hours, more preferably from about one to six hours, even more preferable from between about four to six hours during the decontamination period or cycle. Preferably, it is desirable to maintain an oxidant concentration in the cockpit or passenger compartment of less than 0.1 ppm, more

preferably less than about 0.06 ppm, even more preferably between about 0 to 0.05 ppm during the decontamination period or cycle.

At preferable levels, the effectiveness of the decontamination is surprisingly increased, while at the same remaining within acceptable ozone level limits as determined by the EPA. The article "Ozone Monograph: Toxicity and Evaluation" by Robert Olcrest Ph.D CIH, CHCM, CSP, copyright 1990, which reports 0.5 PPM is well below the limit set by the EPA in 1978 as 120 parts per billion (equivalent to 235 micrograms / cubic meter of air) or a .12 PPM exposure for no more than one hour during any day of the year, exemplifies some of these necessary limitations.

In a further preferred method of the present invention, controlling an undesirable level of ozone in the passenger or cockpit area is also achieved by providing a sensor means, creating a feedback loop utilizing an ozone sensor which sends a signal via a controller means, and, in particular a 'vehicle controller', to the ozone generator or other control means; and modifying the delivery of the ozone to the HVAC unit in response to the signal from the sensor means. Also preferred are embodiments wherein a vehicle owner/operator control means ('switch') is provided to allow the operator or occupant direct control of vehicle ignition (ignition switch) or oxidant generation (oxidant, or, particularly ozone generator switch). More preferred are embodiments wherein the feedback loop is controlled throughout the air treatment system via a vehicle body controller.

In an even more preferred method, the distribution of the ozone within the HVAC system is done by gravity feed.

In Figure 1, an HVAC apparatus, in accordance with an aspect of the present invention is disclosed. An ozone generation system comprising the HVAC system, ozone generator and sensor means and control means, is preferably provided. In Figure 2, molecular oxygen that has been converted to its second allotrope (ozone) in the presence of electric discharge is described:

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An ozone generator (1) is mounted to HVAC unit (2), above evaporator (3) and heater core (4), in the air path (5), downstream from blower wheel (6), above or before temperature door (7), and mode door (8). The ozone generator is electrically wired (9), to the vehicle body controller (10). The vehicle body controller is electrically wired to the control (ignition switch) (11), blower motor (12), passenger compartment ozone sensor (13), occupant 'ozone generator mode' or ozone generator switch (14), door ajar sensor (15), and vehicle battery (16), climate control head (17), and timer function (18).

In a preferred embodiment of the present invention, the HVAC apparatus ozone generator's operation may be directly managed by the vehicle owner/operator or other occupant by placing the generator in one of three operating modes: off; manual; or automatic.

The ozone generator switch (14) is accessible to the vehicle owner/operator or other occupant as a function in the cockpit or passenger compartment preferably on the instrument panel or by other means such as remote lock/unlock switch, keyless entry switch, and glove box switch. When in the "off" mode the vehicle body controller (10) will not activate the timer (18) or other system functions. When in "manual" mode the body controller (10) operates the ozone generation system according to the following parameters:

-the system will not operate if the door ajar sensor (15) is activated;
-if functioning the system will be deactivated if the door ajar sensor (15) is activated;
-the system will not operate if the key is in the ignition (11); and
-the system will not operate if the ozone sensor (13) detects an unacceptable level of ozone in the vehicle interior. The sensitivity of the sensor is preset according to the laws, regulations, or other parameters specific to where the vehicle was purchased or other rationale.

When operating for exemplary purposes, the generator is set, the body controller (10) initiates the timer (18) to operate the ozone generator (1) for a fixed period, preferably from about one to six hours, more preferably from about four to six hours, most preferably for about four hours, depending on the concentration of oxidant provided in the 'closed' HVAC unit for one four hour cycle. The body controller will not initiate the process again until the manual switch is reset by the owner/operator or other occupant.

When in automatic mode the system function remains the same during the, for example, four hour cycle time as described above (same in the manual mode, with the limitations as described above). During the activation period (four hour cycle) the interior of the HVAC unit is provided with enough ozone to more or less completely permeate the heat exchangers and interior of the HVAC unit. If any internal door or doors block access to one of the exchangers the control head (17) will be initiated to move the door (7) or (8) to a favorable position. The control head (17) will also be initiated by the body controller (10) to close the floor discharge opening.

Several micro-organisms may be controlled in preferred aspects of the present invention, particularly where low concentration levels or short exposure times to ozone as oxidant are provided. Particularly susceptible micro-organisms include bacteria and yeast.

Several embodiments of the present invention could be developed from the basic types of HVAC architecture. In preferred embodiments of the present invention where gravity feed cannot be utilized to completely disinfect the HVAC system, a combination of gravity feed and system ventilation can be used to perfuse the HVAC unit and associated ducts. In preferred embodiments, the ozone generator may be attached to the air inlet housing to improve the circulation of the ozone; preferably control of the blower related thereto leads to better air mixing, and, thus, more efficient use of ozone, in these preferred embodiments